

Liquid Crystal Elastomer Membranes and the Wrinkling Instability

Completed Technology Project (2014 - 2018)



Project Introduction

In its technology roadmap, NASA has expressed a desire to develop tailorable materials to better enable design and deployment of lightweight, efficient space structures. For instance, lightweight, easily deployable and inflatable reflectors have garnered particular interest to replace conventional unwieldy mirrors for use on space probes. Recent attempts to utilize polymer membrane technology as deployable substrate for a reflector have faced many technical hurdles: one limitation has been achieving the high surface accuracy required; another has been the presence of surface wrinkling under the complex boundary conditions necessary to pull the membrane taut. We conjecture that the wrinkling phenomenon can be limited or even suppressed completely by utilizing a novel polymer based Liquid Crystal Elastomer material as constituent for the membrane. Consequently, we propose to research the mechanics of Liquid Crystal Elastomer membranes, with emphasis on understanding the wrinkling behavior exhibited by these structures. We believe the prospect of developing a wrinkle-free membrane utilizing this material is exciting, and merits the attention and funding of NASA as it seeks to update its space technology infrastructure with innovative lightweight structures and tailorable materials. In a broader context, the interplay between structural and material non-linearities highlighted by this proposed research raises fundamental questions in mechanics worthy of thesis. In the proposal, we will show a scaling argument that supports the hypothesis. We then propose to develop a numerical scheme that can accurately capture wrinkling mechanics as well as the material nonlinearities of liquid crystal elastomers. This will enable us to investigate realistic space structure geometries, as well as novel complex shapes only possible due to use of liquid crystal elastomer material. We also propose a clamped stretching experiment to further validate our claims.

Anticipated Benefits

This project aims to address technical hurdles associated with using polymer membrane technology as a deployable substrate for a reflector. Lightweight, easily deployable and inflatable reflectors have garnered particular interest to replace conventional unwieldy mirrors for use on space probes.



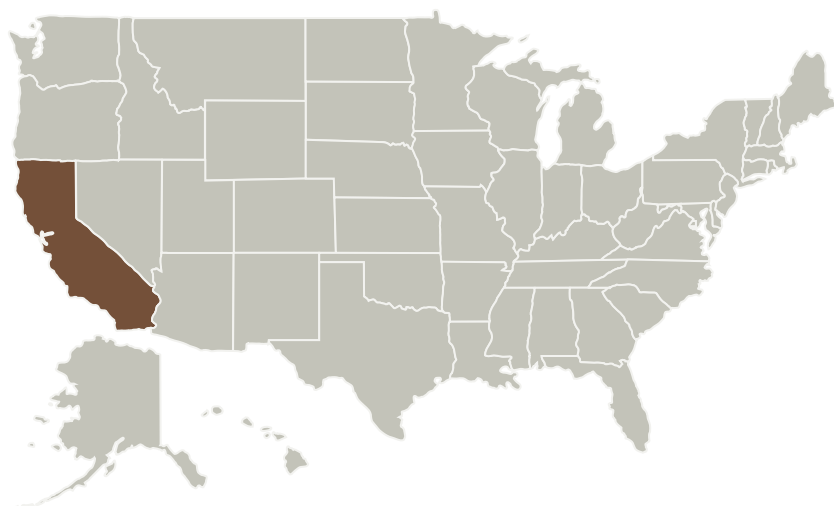
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology (CalTech)	Lead Organization	Academia	Pasadena, California

Primary U.S. Work Locations

California

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

California Institute of Technology (CalTech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Kaushik Bhattacharya

Co-Investigator:

Paul P Plucinsky

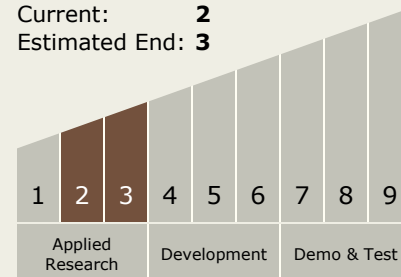
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Technology Maturity (TRL)

Start: 2
Current: 2
Estimated End: 3



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - └ TX12.1 Materials
 - └ TX12.1.7 Special Materials

Target Destination

Outside the Solar System